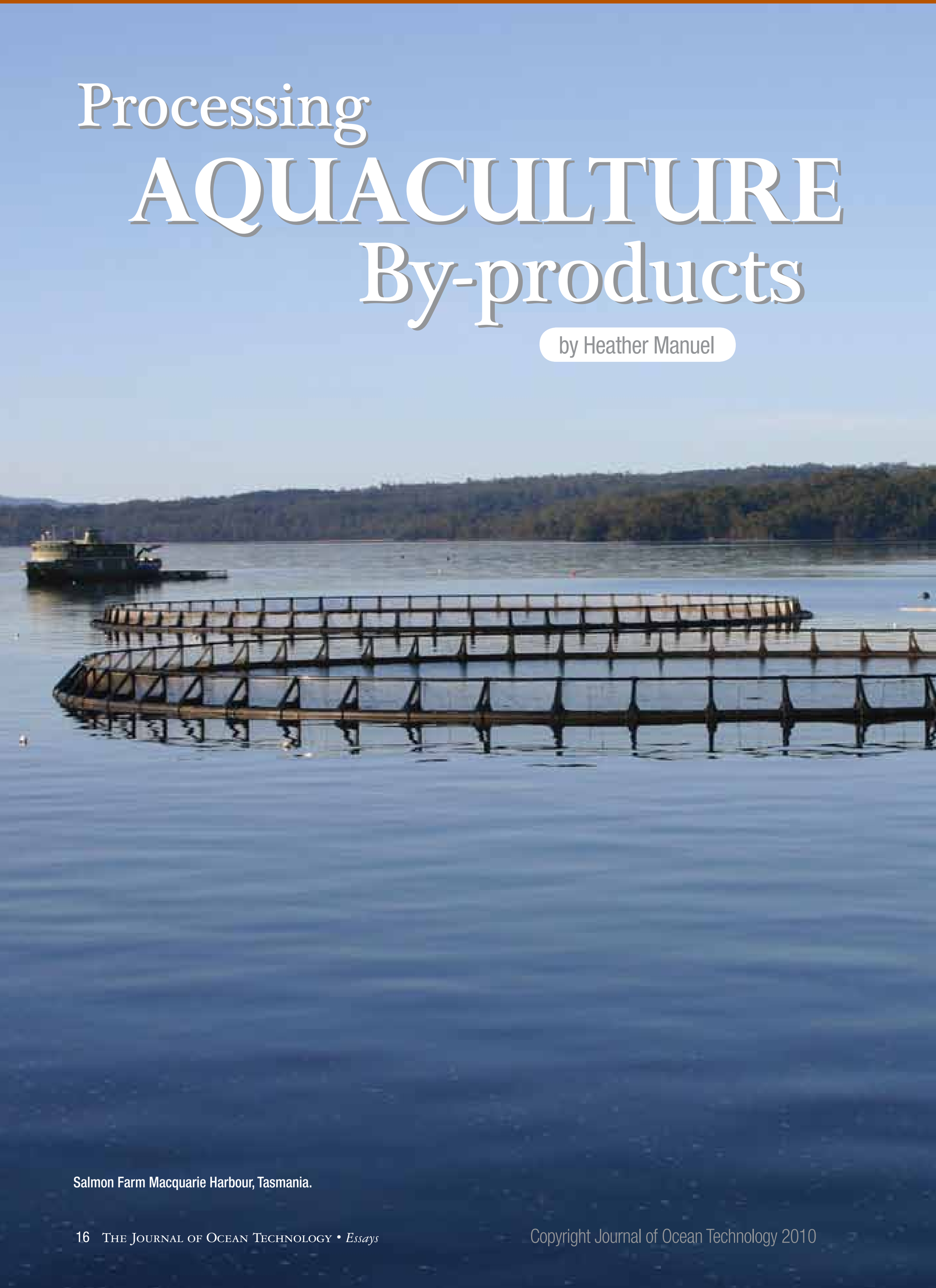
Processing AQUACULTURE By-products

by Heather Manuel



Salmon Farm Macquarie Harbour, Tasmania.

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Global market demand for sustainable seafood products that have a low carbon footprint has increased in recent years. Large seafood buyers such as Sainsbury, Marks & Spencer, and Tesco in the United Kingdom and Wal-Mart in the United States all have programs aimed at monitoring or reducing the global carbon impacts in their supply chains. In Canada, Loblaws recently launched a public awareness campaign to support its efforts to source 100% of seafood sold in its stores from sustainable sources by the end of 2013.

This growing trend towards more sustainable eco-friendly products has created significant challenges for the aquaculture industry as many struggle to meet certification requirements such as that of Global Aquaculture Alliance's Best Aquaculture Practices certification standards. Consumers are much more aware and better educated about the health and environmental impacts of the use of chemicals in aquaculture and seafood production. This increased awareness, coupled with a desire for environmental sustainability, has led many consumers to search for more natural products produced without chemical additives and harvested using sustainable practices.

Processing efficiencies are of particular importance as local companies competing in global markets must be responsive and flexible to industry and consumer needs. They must be able to enhance the quality of and add value to their products while adhering to buyer and market specifications for sustainable eco-friendly products. As global demand for sustainable seafood increases and with the demand for fish protein expected to exceed supply by 2016, the seafood and aquaculture industry can no longer afford the processing inefficiencies of the past which generated about 25 million tonnes per year of fish waste worldwide. Proper waste management will be critical to meet regulatory requirements and the growing ecological and environmental concerns of the local and international markets.

It is estimated that Atlantic Canada produces in excess of 350,000 metric tonnes of waste from

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Fish farm near Peloponnese, Greece.

the fishing and aquaculture industries each year. Newfoundland and Labrador produced in excess of 100,000 metric tonnes of waste from the fishing and aquaculture industries. Shrimp and crab processing discards accounted for more than 79% of this waste; aquaculture accounted for the other majority of the remaining 21%. It is estimated that valuable components of this waste material, such as chitin/chitosan, calcium, and astaxanthin, could be recovered and may be worth anywhere from $75 million to $300 billion U.S. per annum. This is currently unrealized revenue as the materials are discarded in landfill sites and at sea, at a significant cost to the industry and to the detriment of the environment. It has been demonstrated that there are marketable high-value products derived from fishery and aquaculture by-products. These include nutraceuticals (e.g. glucosamine and marine lipids), natural pigments, fish antifreeze proteins, antimicrobial agents, and sources of essential animal nutrients. The commercial production of chitin/chitosan, astaxanthin, and industrial enzymes derived from processing discards has enormous potential value. There is still further potential for new market niches in the pharmaceutical and biomedical industries from as yet unexploited applications. Therefore, the dumping of by-products also represents a significant unrealized loss of revenue to the economy.

Using aquaculture waste materials to develop novel products would greatly help the aquaculture industry meet global market requirements for eco-friendly sustainable seafood products. Full utilization of the resource simply makes sense. Not only is this good for the environment, but it is also good for the bottom line. Full utilization has the potential to improve processing efficiencies, thereby reducing operating costs, and can help generate more revenue for an industry that has traditionally struggled in these areas. According to researchers in Alaska and California, it is possible to expand the seafood by-products market with an impressive array of novel products such as fish oil and protein supplements from fish livers, to antibacterial fish skin gelatin for use in frozen desserts. Some processing companies have been dealing with their waste by producing animal feed, including feed for the aquaculture industry, and fertilizers/compost. There are also several small existing companies that are producing unique products derived from processing discards. In fact, many of the larger fish consortiums are providing the wastes for these smaller companies. However, there are a very limited number of technology based companies in Atlantic Canada that are producing high value end-products, such as glucosamine and omega-3 oils, for world markets, with even fewer such companies operating in Newfoundland and Labrador.

Currently, seafood and aquaculture companies primarily dispose of waste through permits to dump at sea or by dumping in landfills. In addition to the environmental impacts of these actions, there are significant costs to the

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A traditional cage fish farm in the Atlantic Ocean near Tenerife, Spain.

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Salmon oil capsules.

companies for disposal of the waste materials, and significant opportunities are lost to convert these waste materials into value added products that could become additional revenue streams for these companies.

In Newfoundland and Labrador, municipalities across the province are currently restructuring their waste management programs to decrease the amount of organic waste being dumped into landfills. The new waste management strategy will include regional composting facilities for organic waste to which household food waste and seafood processing waste will be diverted. However, when the new waste management strategy is implemented, processors will be charged hefty tipping fees for waste disposal. This may not be a problem for "soft" aquaculture waste (e.g. finfish waste) as demand for this material already exceeds supply in Newfoundland and Labrador. This material is highly sought after for use in fertilizers and composts, aquaculture feeds, pet foods, and fishmeal.

However, in the long term, there is an ongoing need to further support the by-products processing industry and investigate new, innovative molecules or compounds and alternative uses for these biomolecules. There is also a need for technological efficiencies to lower overall production costs of processing

aquaculture by-products. This will increase company profit margins and provide more economic stability for the aquaculture industry.

The rapidly emerging field of marine bioprocessing offers tremendous potential for value addition and product diversification, while at the same time enhancing waste management and cost controls. Marine bioprocessing is any process that uses complete living cells or their components from marine organisms to obtain desired products. Expertise in bioprocess engineering, a specialization of chemical engineering dealing with the design and development of equipment and processes for the manufacture of products like food, feed, pharmaceuticals, nutraceuticals, chemicals and polymers from biological materials, will be a critical success factor for by-product processing.

One of the biggest challenges for marine bioprocessing is the rapid deterioration of waste streams due to microbial activity, enzymatic reactions, hydrolysis and oxidation reactions. As these materials deteriorate it becomes more difficult to further process the materials into value added products. If the raw materials are not immediately used, stabilization technologies are required to minimize deterioration reactions and ensure the raw materials remain suitable for further processing into value added products. However, current stabilization technologies can be costly and can increase the bulk of the materials, which can make transportation more difficult. Thus, cost effective stabilization methods will be critical to success. Stabilization technologies that hold promise include physical separation methods for proteins/lipids that depend on differences in specific gravity (e.g. centrifugation) or differences in surface tension (e.g. skimmers). Other stabilization techniques to consider include ensilaging, hydrolysation, defatting, drying and extrusion processing.

Emerging technologies described as having applications in processing marine by-products include membrane separation; centrifugal partition chromatography; streamline expanded bed separation; counter current extraction; supercritical fluid bioseparation; refractance window drying; microwave drying; and high pressure processing. These sophisticated technologies are needed in by-product processing because the raw materials and end products are extremely biologically fragile, and the markets for the higher end valuable by-products require consistent high-quality products whether these are feedstuffs with consistent protein and amino acid profiles, or pharmaceutical grade chitosan with a consistent oligomer profile. Even lower end composting materials require consistent carbon to nitrogen ratios to produce satisfactory end products. End users of by-products stress the need for consistency of supply in terms of volume and quality.

The grind-and-dump approach to dealing with waste from aquaculture activities is no longer acceptable. In order to supply eco-friendly sustainable seafood products to existing markets, or to develop new markets, a high level of research and development in both product and process design are essential. This type of research will provide more options for processors, and has the potential to increase business opportunities, generate more revenue, and provide more options for the responsible and sustainable use of limited natural marine resources.

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Heather Manuel holds B.Sc. (Hons) (Biochemistry), M.Sc. (Food Science), and M.B.A. degrees from Memorial University as well as a number of certificates in fields related to food science and technology, quality assurance, food safety, HACCP, product development and commercialization, and biotechnology. She recently obtained certification from the British Retail Consortium as an approved BRC Third Party Auditor to the Global Standard for Food Safety (Issue 5).

Ms. Manuel has over 16 years experience in the food/seafood industry and has held a range of managerial and research positions. During these 16 years, she has worked as a production supervisor, a food scientist, a quality management program supervisor, an instructor in Food Technology and Food Safety, and held the position of Chair, Marine Biotechnology within the School of Fisheries, Marine Institute. In 2005 Ms. Manuel was appointed as the Director of the Marine Institute's Centre for Aquaculture and Seafood Development (CASD). CASD employs 15 scientists and technicians and undertakes approximately (Cdn.)$1 million per annum in contractual technical support services to the seafood and aquaculture sectors. In this role, Ms. Manuel has developed further business opportunities for the CASD in the areas of aquaculture, aquatic health, food and seafood processing, and waste management. Ms. Manuel has participated in international missions to China, Iceland, and Ireland to investigate possible collaborations with universities and industry associations in areas related to food technology and aquaculture.

In addition to the high level of management and project design expertise that Ms. Manuel brings to the CASD, she has a broad knowledge of food and seafood processing operations, marine by-products utilization, and the marine biotechnology industry. Ms. Manuel is a founding member and sits on the board of directors of FoodTech Canada; has recently been elected to the board of directors of the Pan American Marine Biotechnology Association; and is a member of the Newfoundland and Labrador Agrifood Advisory Committee.